Characterizing Sampling Frames in Software Engineering Surveys

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Abstract. Questionnaire-based Survey is a study strategy commonly applied in Software Engineering. It allows the researchers to perform descriptive large-scale investigations without the rigorous control level required by experiments. A critical issue on planning surveys concerns with the characterization of adequate sampling frames and their units of analysis. Therefore, this paper presents the results of a structured review in order to identify how sampling frames and units of analysis have been usually characterized in Software Engineering surveys. This investigation allowed to observe the predominant behavior of sampling by convenience whitin units of analysis composed by individuals retrieved from non-representative sources of sampling. Besides, it was also identified many other design alternatives. Based on these results , a set of recommendations on characterizing sampling frames for software engineering surveys, including the attributes gathered from each kind of unit of analysis (organization, individual, project), is presented aiming at supporting future surveys studies in software engineering.

Keywords: surveys, sampling frame, unit of analysis, unit of observation, sampling, systematic literature review

1 Introduction

Survey is one of the most frequently used study strategy for conducting primary studies in Software Engineering (SE). It allows researchers to perform descriptive (questionnaire based) investigations in large-scale without the rigorous control level requested by (*quasi*) experiments. The survey shall support its repetition through several trials and allows the aggregation of its trials results. For this purpose, it is expected that survey plan's components are clearly and systematically established, including its *sampling frame* [1][2].

Adequate sampling frames allow researchers on sampling representative (in randomness, pertinence and heterogeneity) subsets of *units of analysis* from the point of view of certain known *attributes* of the survey's *target audience* [3]. In this case, units of analysis may be represented by each individual (respondent) or by a group of individuals, such as *project teams* and *organizations,* participating in the survey.

However, one can see that establishing adequate sampling frames for a SE survey is not an easy task. Even when the unit of analysis is going to be an individual, it is hard to identify relevant and available *sources of sampling* for supporting the establishment of adequate individuals (sampling frame) to take part in the survey. As consequence, the interpretation of the survey's results is significantly limited [4].

Aiming at to observe how sampling frames have been characterized in SE surveys, this paper presents the results of a secondary study performed over the proceedings of two well-known international conferences devoted to empirical software engineering (ESEM and EASE), aiming at identifying how researchers have worked with the identification and selection of participants in SE surveys. Data from 45 surveys were analyzed in which was identified that most of them use a specific source of sampling for composing their sampling frames. However, probabilistic sampling designs are rarely applied. The results from this study also allowed us to identify a set of *attributes* frequently used for characterizing individuals and organizations in SE surveys. Then, based on the survey findings and on these authors' previous experience on replicating surveys [5][6][7] and developing conceptual frameworks for supporting sampling in SE surveys [4], a set of recommendations for characterizing sampling frames, which can be useful for the researchers and practitioners interested in performing surveys in SE, is presented.

To support all the discussion, besides this introduction this paper is organized as follows. Section 2 (background section) explains and exemplifies the concepts related with sampling frame used in the paper. Section 3 presents the secondary study plan, its execution and discusses its results. Section 4 presents a set of recommendations on characterizing sampling frames for SE surveys. Next, some conclusions are presented in Section 5.

2 Background

The following subsections describe the main concepts related with the characterization of sampling frames used in our investigation. These concepts and their relationships are illustrated in Figure 1.

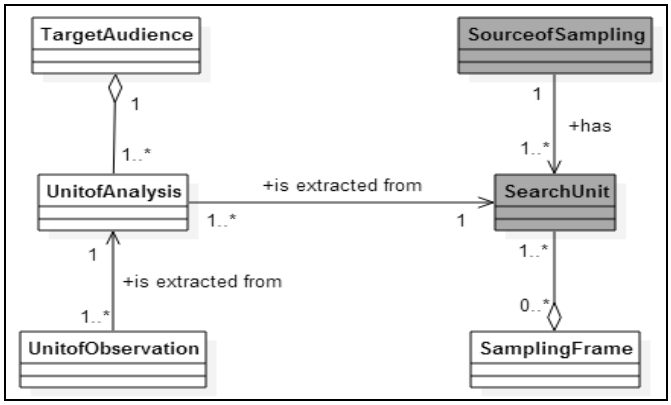

Figure 1. Concepts related with sampling frame and their relationships in SE surveys.

When the *population* for a survey is defined, it can be considered that its *target audience*, i.e., who are its intended respondents, was established [1]. A target audience tries to answer who can best provide the information needed in order to achieve the *research objective*. The *unit of observation* is the minimum component from which data can be retrieved and analyzed from a study [8]. In the case of questionnaire-based surveys, the *respondent* (individual) must be the unit of observation. In the other hand, the *unit of analysis* is the major entity that is used for analyzing the study results [8]. Thus, in questionnaire based surveys, the unit of analysis can be an *individual* or *groups of individuals* naturally established, such as *households*, *teams*, *organizations,* among others.

Observing in the large, it can be considered that the unit of analysis is in the level at which the researchers *pitch the conclusions* while the unit of observation is in the level at which researchers *collect data*. Thus, it is expected to extract a set of representative units of analysis from a specific source of samples in order to compose a *sampling frame*, i.e., the frame from which *samples* will be selected for conducting the study [9]. However, due to the limitations on identifying adequate sources of samples in SE surveys, many distinct arrangements may be used for indirectly retrieving units of analysis.

For instance, in order to gather representative opinion from SE researchers (unit of observation/ unit of analysis) regarding characteristics of agility in the software process [10], it was established a *sampling frame* composed by a small (but representative) subset of 19 groups of interest from the professional social network *LinkedIn* (www.linkedin.com) [6].

To better deal with these limitations, de Mello et al. [4] introduced the concepts of *source of sampling* and *search unit*. A *source of sampling* consists on a database (automated or not) from which adequate *subpopulations* from the *target audience* can be *randomly* sampled and *systematically retrieved* in order to compose a valid *sampling frame*.

A *search unit* characterizes how units can be retrieved from a specific *source of sampling*. Ideally, each search unit must have a one-to-one correspondence with the *unit of analysis*, allowing composing a *sampling frame* compatible with the survey's *target audience* [4]. However, SE researchers must be able to deal with sources' limitations from where samples can be extracted, as exemplified in [6] when *groups of interest* were established as *search units* and 19 of them where selected to compose the *sampling frame.* To be considered valid, a *source of sampling* should satisfy, at least, the following *essential requirements* (ER) [4]:

- *ER1. A source of sampling should not intentionally represent a segregated subset from the target audience*, i.e., for a target audience "X", it is not adequate to search for units from a source *intentionally designed* to compose a specific subset of "X".
- *ER2. A source of sampling should not present any bias on including on its database preferentially only subsets from the target audience.* Unequal criteria for including search units mean unequal sampling opportunities.
- *ER3. All source of sampling search units and their units of observation must be identified by a logical or numerical id.*

- *ER4. All source of sampling' search units must be accessible*. If there are hidden search units, it is not possible to contextualize the population.

Intending to make these concepts more clear, let's assume a researcher needs to perform an opinion survey having the *Brazilian Research Groups in SE* as ***target audience***, a relevant ***source of sampling*** can be represented by the CNPq research group directory (http://dgp.cnpq.br/dgp/). However, this source is not dedicated only to SE research. Thus, a ***sampling frame*** may be established applying a set of simple criteria for filtering all research groups related with "software engineering". In this scenario, ***search units*** and ***units of analysis*** are the same (*research groups*), while each ***unit of observation*** is a *research group member*. Then, after composing the sampling frame as illustrated in Figure 2, it can be chosen one of the following sampling designs:

- Recruit all members from all research groups (census);
- Recruit all members from a random subset of groups (simple random sampling);
- Recruit a random subset of members from each group randomly selected (clustered sampling);

A complete description about using the framework concepts can be found at [3], which is based on the recruitment plan designed to a large scale survey on characteristics of agility and agile practices in software processes [6].

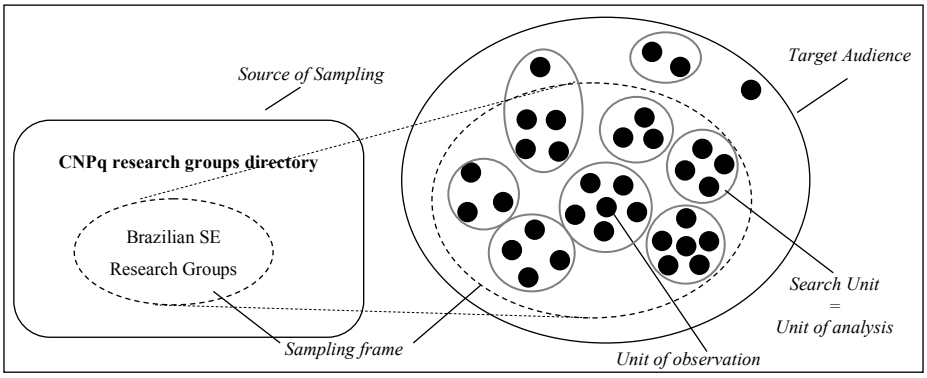

Figure 2. An example of sampling research groups for a survey

3 The Secondary Study: Structured Review

To make possible the description of guidelines for supporting the use of the aforementioned framework by researchers on sampling in SE surveys, it was designed a structured review aiming at investigating how sampling frames have been characterized in SE surveys. As far as we aware, this is the first review addressing such topic in SE. This structured review does not intend to be as rigorous and complete as a systematic literature review (SLR) but has been based in its principles, borrowing some important concepts such as the overall features regarding the structuring of research questions and simplified search strings, reducing the overall coverage but allowing us

to observe the target features of our study. Following subsections presents the survey plan, its execution and discuss its results.

3.1 Structure Review Plan

The population of the secondary study is composed by technical papers (primary studies) presenting SE questionnaire-based surveys. In order to perform a more objective investigation, it was established the published proceedings of the International Symposium on Empirical and Assessment on Software Engineering (EASE) and the International Symposium of Empirical Software Engineering and Measurement (ESEM, named ISESE until 2007) as population. Considering the specialized population, only the *keyword* "survey" will be used as *search string*. Then, abstracts from each retrieved paper will be analyzed in order to evaluate whether each paper must be included or not, based on the following inclusion and exclusion criteria.

1. It will be included only papers in which the abstract suggests that a plan of at least one survey is presented;
2. It will be excluded all survey papers in which the abstract explicitly shows that individuals are not the unit of observation, as expected in questionnaire based surveys. It is the case of *literature surveys* and *documentation surveys.*

All papers included after abstract analysis and available for download will be fully-read, being collected the following data from each identified survey: *paper characterization* (Title, authors, year, conference name); *survey trial identification* (first trial or replication?); *target audience*; *unit of observation and its attributes*; *unit of analysis and its attributes*; *source(s) of sampling; search unit(s) and its attributes; sampling frame; sampling design; evidence using of the collected attributes to support results analysis.*

3.2 Execution and Results

The Structured Review was conducted in October, 2014 to allow the inclusion of 2014 ESEM and EASE proceedings. It is important to highlight that only the ESEM (ISESE) proceedings since 2005 and EASE proceedings since 2010 were digitally available in the Scopus (www.scopus.com) search tool. After applying the search string, 82 papers were retrieved. After the abstract analysis, 54 papers were included for full paper reading and data collection, in which was identified 52 distinct surveys. However, it was identified that seven surveys did not make available sufficient data from the point of the view of this study and were excluded. From all analyzed surveys, only three [5][7][23] replicated a previous one, suggesting that SE surveys are not usually replicated.

Table 1 summarizes the 45 analyzed surveys. In the *sampling design* column, "NPS" means that non-probabilistic sampling design was applied in all sampling activities or in part of them, while "PS" means that only a clear probabilistic sampling design was performed over a sampling frame. In the *unit of analysis* and *search unit* columns "I", "P", "O", "OU", "G", "Pp", "ND" means, respectively, the following types of entities: *individuals, projects, organizations, organizational units, groups,*

papers and *not defined*. "Mixed" means that at least two simple entities were applied for a single survey trial. For instance, Basten and Mellis [36] contacted 106 *software professionals* from a network and randomly contacted 70 *companies*, asking for their participation.

Table 1. Surveys retrieved in the Structure Review

Survey	Sampling Design	Unit of Analysis	Search Unit	Survey	Sampling Design	Unit of Analysis	Search Unit
[11]	NPS	I	I	[35]	NPS	I	P
[12]	NPS	I	O	[36]	PS	P	Mixed
[13]	NPS	P	O	[37]	NPS	I	I
[14]	NPS	I	I	[38]	NPS	I	I
[15][16]	NPS	OU	OU	[39]	NPS	I	Mixed
[17]	NPS	I	I	[40]	PS	I	I
[18]	NPS	I	Mixed	[41]	NPS	I	G
[19]	PS	I	I	[42]	NPS	I	I
[20]	NPS	I	I	[43]	NPS	I	O
[21]	NPS	I	Mixed	[44]	PS	I	Pp
[22]	NPS	ND	O	[45]	NPS	ND	I
[23]	NPS	P	O	[5]	PS	I	G
[24]	PS	I	Pp	[46]	PS	I	I
[25]	NPS	I	I	[47]	PS	I	Pp
[26]	NPS	I	O	[48]	NPS	I	I
[27]	NPS	I	O	[49]	NPS	I	I
[28]	NPS	OU	OU	[50]	NPS	I	I
[29]	ND	I	I	[51]	NPS	I	I
[30]	NPS	I	G	[52]	NPS	O	O
[31]	NPS	I	I	[53]	NPS	OU	OU
[32]	NPS	I	I	[7]	PS	I	G
[33]	NPS	I	I	[54]	PS	I	Pp
[34]	NPS	I	Mixed				

One can see in Table 1 that most of analyzed surveys used the entity *individual* as unit of analysis (80%) followed by *organization* (9%) and *project* (7%). It can be also observed that most of surveys (78%) do not follow a probabilistic sampling design. Table 2 distributes the analyzed surveys among all arrangements between the identified unit of analysis and search units, excluding the seven surveys in which "mixed" units were applied.

Half of surveys in Table 2 presents an arrangement of unit of analysis-search unit composed by *individual-individual*. However, from all these 19 surveys, three [19][40][46] followed a probabilistic sampling process over a sampling frame formally established. Begel and Nagappan [19] randomly recruited 2,821 individuals having the developers from a single organization (Microsoft) as sampling frame, approximately 10% from the total sampling frame size. Murphy et al. [46] performed another survey in the same sampling frame, collecting the impression of software developers regarding Agile Practices at the company during six years. The survey presented by Rodríguez et al, [40] highlights the benefits to SE research of accessing a national

database composed by Finnish software professionals and organizations (FIPA). It was established a sampling frame composed by 4,450 Finnish SE practitioners suited to the survey focus, allowing to retrieve a real sample composed by 408 respondents.

Table 2. Distribution of the analyzed surveys between arrangements of identified units. .

Arrangements		**#**	**%**	**References**
Unit of Analysis	**Search Unit**			
Individual	Group	4	10.5%	[5][7][30][41]
	Individual	19	50%	[11][14][17][19][20][25][29][31][32] [33][37][38][40][42][46][48][49][50][51]
	Organization	4	10.5%	[12][26][27][43]
	Papers	4	10.5%	[24][44][47][54]
	Project	1	2.7%	[35]
Organization	Organization	4	10.5%	[15]([16])[28][52][53]
Project	Organization	2	5.3%	[13], replicated in [23]
Total		**38**	**100%**	

It was also observed that six from eight surveys using *organizations* or *organizational units* as search units were performed over sampling frames established by convenience, which reflects the challenge on accessing a comprehensive set of SE organizations. This challenge was overcome by Conradi et al. [13] and Ji et al. [23] in which the researchers searched IT Organizations working with COTS through comprehensive sources of sampling such as yellow pages from four distinct countries (Italy, Germany, Norway [13] and China [23]).

In the case of using *groups* for searching *individuals*, all the retrieved papers used *LinkedIn* as source of sampling. However, they clearly differ in their approaches. Joorabchi et al. [41] reported the selection of *LinkedIn* groups of interest for composing a sampling frame without clear criteria for selecting them. Kanij et al. [30] searched for pertinent groups of interest by filtering them through search string for composing the sampling frame. Then, they decided to select a subset of the retrieved groups. However, in both surveys, the researchers sent recruitment messages using forum groups, hampering the control regarding how many individuals were effectively recruited. In the other hand, de Mello and Travassos [5] and de Mello et al. [7] studies individually invited members from *LinkedIn* groups of interest retrieved by following systematic search plans. As a consequence, it was possible to apply probabilistic sampling designs and then conclude in which extent the results can be generalized to the whole sampling frame [55].

Finally, it is important to highlight that all four surveys applying the arrangement of *individual-papers* were performed based on sampling frames [24][44][47][54] established through the results of SLR previously performed on each survey's context.

3.2.1 Characterizing Entities

The attributes applied on characterizing the identified survey's units (individual, organization, project, group and paper) were also investigated. In some cases, it is important to observe that an attribute was used as *control attribute*, i.e., a restriction for composing the sampling frame, such as *Country* [13][23][40] and *Professional Status* [19]. The following attributes were identified for characterizing *individuals*:

- *Experience in the research context* (57%), collected/ calculated through many indicators such as: *experience level working in the research context* [5][7][29][32][33][35]*, number of projects applying the research context* [5][7][20]*, number of publications in the research context* [7];
- *Current professional role* (51%);
- *SE Experience* (37%), frequently collected/ calculated through similar indicators applied in *experience on the research context;*
- *Country* (35%) typically more used as control attribute;
- *Professional Status* (31%) only used as control attribute;
- *Academic degree* (29%) and its *field* (10%)
- *Gender* (10%) and *Age* (6%)
- *Current Organizational background* (6%), including the following time-oriented indicators: time working with the current team [14][19][20], time working in the current role [50] and time working in the current organization[23][49].

For characterizing *organizations* and/or *organizational units* it was identified the following attributes in the papers using this entity as unit of analysis and/or search unit, ordered by frequency of use:

- *Organization size* (78%), classified in a ordinal scale based on the number of employees;
- *Industry segment* (70%), such as *software, medicine, avionics, finance,* among others;
- *Country* (65%) more used as *control attribute;*
- *Organization type* (48%), also often used as *control attribute*, such as *government, private company, university,* among others;
- *Product type* (17%) delivered;
- *Market* (13%): local, foreign or both;
- *Software Process Improvement* (13%), commonly represented by the organization's CMMI level;
- *Company age* (9%), expressed in years;
- *Strategy for software development* (9%): *in house, outsourcing or reuse*

In addition, although the low rate of units composed by *software projects,* it was identified many attributes, such as: *project size and duration*, *software process applied*, *team size*, *client/ product segment*, *client nature (public or private organization)* and *its physical distribution.* For the *groups* and *papers* only used as search units, few attributes were collected. In fact, only [5][7] collected another group attributes than its name, such as *theme, size* and *language*, contributing for the establishment of each sampling frame. In the case of surveys using units composed by *papers*

all attributes were collected from data extracted in each respective SLR from which such papers were selected.

Finally, it is important to emphasize that although almost all analyzed surveys collect attributes for characterizing their units of analysis, few evidence regarding using such data for supporting the analysis of survey's data was detected. Exceptions can be observed in [7][13][20][33][51]. de Mello et al. [7] used the subjects' SE reported background for stratifying the search units (groups). In addition, subjects' background in the research context (i.e. agility in software processes) was used for comparing the results from each *stratum*. Guo and Seaman [20] crossed background data collected from 38 project managers in order to assess the correlation between *project duration* and *software group size*. Torchiano [33] used the attribute *company size,* collected from each subject to assess the relationship of this attribute's values and the frequency of using model driven engineering. Pfhal [51] crossed some respondents characterization data such as country and current role for investigating trends on using exploratory testing.

4 Recommendations for Characterizing Sampling Frames in SE surveys

Based on the results presented in Section 3 and on our previous experience on conducting SE surveys [3][5][6][7][10][24] and developing conceptual frameworks for supporting sampling in SE surveys [4], this section presents a set of recommendations on characterizing sampling frames for SE surveys.

4.1 Characterizing the unit of analysis

Considering the survey's *target audience*, identify what type of entity must be established as *unit of analysis*. Following is presented a recommended set of minimum attributes to be retrieved for each type of entity commonly applied as unit of analysis in SE surveys. In the case of *individuals*, it can be extended to the units of observation:

- **Individuals:** *country (city), general SE experience, survey context experience, higher academic degree related with software engineering*;
- **Organizations/ Organizational units:** *country* (city); *size* by number of employees (ordinal, following international or local categorizations); *organizational segment* (government, company or academic); *area*; *CMMI level, MPS.BR level* or another *SPI indicator*.
- **Software Projects:** *size* (number of hours estimated or dedicated to), *CMMI level, MPS-BR level* or another *SPI indicator*, *team size*, *team physical distribution* (in site/ distributed/ globally distributed), *product segment*.

In fact, many other attributes may be necessary considering each survey context. Some of these attributes may restrict the composition of the sampling frame *(control attribute)*, as exemplified in the section 3.2.1.

4.2 Establishing the source of sampling and its search unit

When the access to the whole target audience is not available, investigate *sources of sampling* available having *search units* compatible with the unit of analysis and its restrictions. For instance, the Lattes platform (CNPq open environment available atlattes.cnpq.br) can be considered an interesting source for searching Brazilian project managers since any professional can register and update his/her *curriculum* on it. It is important to highlight that only one source of sampling shall be selected for each survey trial in order to support adequate results interpretation [4].

Depending on the unit of analysis, the following type of sources of sampling may be considered (search units in italic):

- **SE Conferences:** *individuals* assisting to relevant SE conferences can be eventually considered a small but representative set of individuals for many surveys contexts [33][50];
- **Discussion Groups:** an active and thematic SE discussion group can be considered as good source for sampling *individuals* [17];
- **Projects repositories:** retrieving a representative dataset from *software projects*, including data from the project team, is a challenge. Typically, data from several projects can be retrieved in the context of open source projects [56].
- **Digital Libraries:** when it is expected that units of analysis are restricted to *researchers*, Digital libraries such as SCOPUS and IEEE can be used for retrieving relevant authors of *papers* in the survey's context [10][24][44][47][54];
- **Catalogues:** searching for National or International catalogues provided by institutes [40], governments [13] or even yellow pages [13] may be considered for retrieving representative sets of *organizations* or *individuals*;
- **Professional Social Networks:** it has demonstrated to be a promising technology for supporting large scale sampling of *individuals* [3][5][6][7]. However, limitations on accessing searching units must be taken into account [4];
- **Freelancing tools:** this sort of tool allows the retrieving and hiring of *individuals* identified as SE professionals for specific tasks. However, it could be significantly expensive to sample *individuals* using such technology [4];

Take in mind to choose a source of sampling supporting at least the *essential requirements* presented in Section 2. Preferentially, identify sources where the search unit and the unit of analysis are represented by the same entity. Alternatively, other arrangements can be applied (for instance, searching companies for analyzing individuals, searching groups of interest for analyzing individuals, searching papers for analyzing individuals). However, avoid combining search units composed by subsets from each unit of analysis (for instance, searching companies from individuals). In such cases, the control of sampling frame representativeness can be hampered. For instance, whether identified, after the survey execution, that five subjects work in the same large organization, this sample will be not representative to develop any conclusion in the context of such organization. If no valid source of sampling is available for the survey context, consider revising the survey *target audience*.

4.3 Characterizing the sampling frame

Since the source of sampling and its search unit are characterized, a systematic approach for retrieving only valid search units for composing the *sampling frame* must be provided. In this context, it is important to define a *search string* and a search algorithm to apply it, performing an initial filtering in the source. Then, *exclusion criteria* may be applied, as presented in [4] and exemplified in [5][6].

In some cases, more data than available in each search unit shall be provided before supporting the application of the *exclusion criteria*. For instance, if the units of analysis from a survey are only software companies having more than 50 employees, all available software companies in a generic source could be first contacted in order to verify such size restriction.

5 Conclusion

This paper presented a structured review conducted in order to identify how sampling frames have been characterized in SE surveys. 45 studies published in ESEM and EASE conferences were analyzed. It was observed that most of them established a sampling frame by convenience having individuals as unit of analysis. However, many alternative designs were identified in order to overcome the limitations on establishing adequate sampling frames in SE surveys. Then, a set of recommendations for characterizing sampling frames were presented. Such recommendations include alternative sources of sampling that could be applied depending on the research context, guiding researchers on how to retrieve relevant units of analysis from search units represented by *organizations*, *individuals*, *software projects*, *papers* and *groups of interest*. In addition, a set of minimum attributes is proposed for characterizing the common units of analysis identified in SE surveys: *individuals*, *organizations* and *software projects*.

It is expected this work supports SE researchers on mitigating the external threats to validity commonly reported in SE surveys. Since such recommendations are addressed to issues regarding SE research, they do not include any statistical concepts and formulas concerned with sampling. They also not establish specific sampling frames for any survey context, but we believe they can represent a contribution for future standardizations. As next step and after extending the structured review to strength evidence, these recommendations will be used to compose a set of guidelines for supporting sampling in SE surveys.

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References

1. Kasunic, M.: Designing an Effective Survey. TR CMU/SEI-2005-HB-004, Carnegie Mellon University (2005)
2. Kitchenham, B.A., Pfleeger, S.L.: Personal Opinion Surveys. In: Shull, F., Singer, J., and Sjøberg, D.I.K. (eds.) Guide to Advanced Empirical Software Engineering. pp. 63–92. Springer London (2008).
3. De Mello, R.M., da Silva, P.C., Travassos, G.H.: Investigating Probabilistic Sampling Approaches for Large-Scale Surveys in Software Engineering. In: Journal of Software Engineering Research and Development *(In press)*.
4. De Mello, R.M., da Silva, P.C., Runeson, P., Travassos, G.H.: Towards a Framework to Support Large Scale Sampling in Software Engineering Surveys. In: Proc. 8th ACM/IEEE ESEM. pp. 48:1–48:4 (2014).
5. De Mello, R.M., Travassos, G.H.: Would Sociable Software Engineers Observe Better? In: Proc. 7th ACM / IEEE ESEM. pp. 279–282 (2013).
6. De Mello, R.M., da Silva, P. C., Travassos, G.H.: Investigating Probabilistic Sampling Approaches for Large-Scale Surveys in Software Engineering. In: Proc. 11th CIbSE/ ESELAW (2014).
7. De Mello, R.M., da Silva, P.C., Travassos, G.H.: Sampling Improvement in Software Engineering Surveys. In: Proc. 8th ACM/IEEE ESEM. pp. 13:1–13:4 (2014).
8. Hopkins, K.D.: The Unit of Analysis: Group Means Versus Individual Observations. American Education Research Journal. 19, 5–18 (1982).
9. Thompson, S.K.: Sampling. Wiley, Hoboken, N.J (2012).
10. Abrantes, J. F., Travassos, G. H.: Towards Pertinent Characteristics of Agility and Agile Practices for Software Processes. CLEI Electronic Journal, vol. 16(1) (2013).
11. Hogganvik, I., Stolen, K.: Risk analysis terminology for IT-systems: does it match intuition? In: Proc. 5thACM/IEEE ISESE (2005).
12. Glynn, E., Fitzgerald, B., Exton, C.: Commercial adoption of open source software: an empirical study. In: Proc. 5th ACM/IEEE ISESE (2005).
13. Conradi, R., Li, J., Slyngstad, O.P.N., Kampenes, V.B., Bunse, C., Morisio, M., Torchiano, M.: Reflections on conducting an international survey of software engineering. In: Proc. 5th ACM/IEEE ISESE, pp. 214-223 (2005).
14. Slyngstad, O.P.N., Gupta, A., Conradi, R., Mohagheghi, P., Rønneberg, H., Landre, E.: An Empirical Study of Developers Views on Software Reuse in Statoil ASA. In: Proc. 6th ACM/IEEE ISESE, pp. 242–251. ACM, New York, NY, USA (2006).
15. Taipale, O., Smolander, K.: Improving Software Testing by Observing Practice. In: Proc. 6th ACM/IEEE ISESE, pp. 262–271. ACM, New York, NY, USA (2006).
16. Taipale, O., Karhu, K., Smolander, K.: Observing Software Testing Practice from the Viewpoint of Organizations and Knowledge Management. In: Proc. 1st ACM/IEEE ESEM, pp. 21–30 (2007).
17. Nugroho, A., Chaudron, M.R.V.: A Survey of the Practice of Design – Code Correspondence amongst Professional Software Engineers. In: Proc.1st ACM/IEEE ESEM, pp. 467–469 (2007).
18. Jedlitschka, A., Ciolkowski, M., Denger, C., Freimut, B., Schlichting, A.: Relevant Information Sources for Successful Technology Transfer: A Survey Using Inspections as an Example. In: Proc. 1st ACM/IEEE ESEM, pp. 31–40 (2007).
19. Begel, A., Nagappan, N.: Pair Programming: What's in It for Me?. In: Proc. 2nd ACM/IEEE ESEM, pp. 120–128. (2008).

20. Guo, Y., Seaman, C.B.: A Survey of Software Project Managers on Software Process Change. In: Proc. 2nd ACM/IEEE ESEM, pp. 263–269. (2008).
21. Nugroho, A., Chaudron, M.R.V.: A Survey into the Rigor of UML Use and Its Perceived Impact on Quality and Productivity. In: Proc. 2nd ACM/IEEE ESEM, pp. 90–99. (2008).
22. Yang, D., Wang, Q., Li, M., Yang, Y., Ye, K., Du, J.: A Survey on Software Cost Estimation in the Chinese Software Industry. In: Proc. 2nd ACM/IEEE ESEM, pp. 253–262. (2008).
23. Ji, J., Li, J., Conradi, R., Liu, C., Ma, J., Chen, W.: Some Lessons Learned in Conducting Software Engineering Surveys in China. In: Proc. 2nd ACM/IEEE ESEM, pp. 168–177. (2008).
24. Dias Neto, A.C., Travassos, G.H.: Surveying Model Based Testing Approaches Characterization Attributes. In: Proc. 2nd ACM/IEEE ESEM, pp. 324–326. (2008).
25. França, A.C.C., da Silva, F.Q.B.: An Empirical Study on Software Engineers Motivational Factors. In: Proc. 3rd ACM/IEEE ESEM, pp. 405–409 (2009).
26. Odzaly, E.E., Greer, D., Sage, P.: Software risk management barriers: An empirical study. In: Proc. 3rd ACM/IEEE ESEM, pp. 418–421 (2009).
27. França, A.C.C., da Silva, F.Q.B., de Sousa Mariz, L.M.R.: An Empirical Study on the Relationship between the Use of Agile Practices and the Success of Scrum Projects. In: Proc. 4th ACM/IEEE ESEM, pp. 37:1–37:4. (2010).
28. Kasurinen, J., Taipale, O., Smolander, K.: Test Case Selection and Prioritization: Risk-based or Design-based?. In: Proc. 4th ACM/IEEE ESEM, pp. 10:1–10:10. (2010).
29. Nguyen-Hoan, L., Flint, S., Sankaranarayana, R.: A Survey of Scientific Software Development. In: Proc. 4th ACM/IEEE ESEM, pp. 12:1–12:10 (2010).
30. Kanij, T., Merkel, R., Grundy, J.: A Preliminary Study on Factors Affecting Software Testing Team Performance. In: Proc. 5th ACM/IEEE ESEM. pp. 359–362 (2011).
31. Southekal, P.H., Levin, G.: Formulation and Empirical Validation of a GQM Based Measurement Framework. In: Proc. 5th ACM/IEEE ESEM . pp. 404–413 (2011).
32. Tofan, D., Galster, M., Avgeriou, P., Weyns, D.: Software engineering researchers' attitudes on case studies and experiments: An exploratory survey. In: Proc. 15th EASE, pp. 91–95 (2011).
33. Torchiano, M., Tomassetti, F., Ricca, F., Tiso, A., Reggio, G.: Preliminary Findings from a Survey on the MD State of the Practice. In: Proc. 5th ACM/IEEE ESEM, pp. 372–375 (2011).
34. Laukkanen, E.I., Mäntylä, M.V.: Survey Reproduction of Defect Reporting in Industrial Software Development. In: Proc. 5th ACM/IEEE ESEM, pp. 197–206 (2011).
35. Nunnenmacher, S., Jung, J., Chehrazi, G., Klaus, A., Lampasona, C., Webel, C., Ciolkowski, M.: A Preliminary Survey on Subjective Measurements and Personal Insights into Factors of Perceived Future Project Success. In: Proc. 5th ACM/IEEE ESEM, pp. 396–399 (2011).
36. Basten, D., Mellis, W.: A Current Assessment of Software Development Effort Estimation. In: Proc. 5th ACM/IEEE ESEM, pp. 235–244 (2011).
37. Kusumo, D.S., Staples, M., Zhu, L., Jeffery, R.: Analyzing Differences in Risk Perceptions Between Developers and Acquirers in OTS-based Custom Software Projects Using Stakeholder Analysis. In: Proc. 6th ACM/IEEE ESEM, pp. 69–78 (2012).
38. Tomassetti, F., Torchiano, M., Tiso, A., Ricca, F., Reggio, G.: Maturity of software modelling and model driven engineering: A survey in the Italian industry. In: Proc. 16th EASE, pp. 91–100 (2012).

39. Zhang, C., Budgen, D., Drummond, S.: Using a Follow-on Survey to Investigate Why Use of the Visitor, Singleton & Facade Patterns is Controversial. In: Proc. 6th ACM/IEEE ESEM, pp. 79–88 (2012).
40. Rodríguez, P., Markkula, J., Oivo, M., Turula, K.: Survey on Agile and Lean Usage in Finnish Software Industry. In: Proc. 6th ACM/IEEE ESEM, pp. 139–148 (2012).
41. Joorabchi, M.E., Mesbah, A., Kruchten, P.: Real Challenges in Mobile App Development. In: Proc. 7th ACM/IEEE ESEM, pp. 15–24 (2013).
42. Cavalcanti, Y.C., da Mota Silveira Neto, P.A., do Carmo Machado, I., de Almeida, E.S., de Lemos Meira, S.R.: Towards Understanding Software Change Request Assignment: A Survey with Practitioners. In: Proc. 17th EASE, pp. 195–206 (2013).
43. Humayun, M., Gang, C., Masood, I.: An Empirical Study on Investigating the Role of KMS in Promoting Trust Within GSD Teams. In: Proc. 17th EASE, pp. 207–211 (2013).
44. Carver, J.C., Hassler, E., Hernandes, E., Kraft, N.A.: Identifying Barriers to the Systematic Literature Review Process. In: Proc. 7th ACM/IEEE ESEM, pp. 203–212 (2013).
45. Fernández, D.M., Wagner, S.: Naming the Pain in Requirements Engineering: Design of a Global Family of Surveys and First Results from Germany. In: Proc. 17th EASE, pp. 183–194 (2013).
46. Murphy, B., Bird, C., Zimmermann, T., Williams, L., Nagappan, N., Begel, A.: Have Agile Techniques been the Silver Bullet for Software Development at Microsoft? In: Proc. 7th ACM/IEEE ESEM, pp. 75–84 (2013).
47. Santos, R.E.S., Da Silva, F.Q.B.: Motivation to Perform Systematic Reviews and their Impact on Software Engineering Practice. In: Proc. 7th ACM/IEEE ESEM, pp. 292–295 (2013).
48. Senapathi, M., Srinivasan, A.: An Empirical Investigation of the Factors Affecting Agile Usage. In: Proc. 18th EASE, pp. 10:1–10:10 (2014).
49. Diebold, P., Lampasona, C., Zverlov, S., Voss, S.: Practitioners' and Researchers' Expectations on Design Space Exploration for Multicore Systems in the Automotive and Avionics Domains: A Survey. In: Proc. 18th EASE, pp. 1:1–1:10 (2014).
50. Monasor, M.J., Noll, J., Vizcaíno, A., Piattini, M., Beecham, S.: Walk Before You Run: Using Heuristic Evaluation to Assess a Training Tool Prototype. In: Proc. 18th EASE, pp. 41:1–41:10 (2014).
51. Pfahl, D., Yin, H., Mäntylä, M.V., Münch, J.: How is Exploratory Testing Used? A State-of-the-practice Survey. In: Proc. 8th ACM/IEEE ESEM, pp. 5:1–5:10 (2014).
52. Diebold, P., Vetrò, A.: Bridging the Gap: SE Technology Transfer into Practice: Study Design and Preliminary Results. In: Proc. 8th ACM/IEEE ESEM, pp. 52:1–52:4 (2014).
53. Moe, N.B., Šmite, D., Šāblis, A., Börjesson, A.-L., Andréasson, P.: Networking in a Large-scale Distributed Agile Project. In: Proc. 8th ACM/IEEE ESEM, pp. 12:1–12:8. (2014).
54. Guzmán, L., Lampasona, C., Seaman, C., Rombach, D.: Survey on Research Synthesis in Software Engineering. In: Proc. 18th EASE, pp. 2:1–2:10. (2014).
55. de Mello, R.M., da Silva, P. C., Travassos, G. H.: Agilidade em Processos de Software: Evidências Sobre Características de Agilidade e Práticas Ágeis. In: Proc. XIII SBQS. Blumenau, Brazil (2014). *(in Portuguese)*
56. Bettenburg, N., Just, S., Schröter, A., Weiss, C., Premraj, R., Zimmermann, T.: What Makes a Good Bug Report?. In: Proc. 16th ACM SIGSOFT International Symposium on Foundations of Software Engineering. pp. 308–318. (2008).